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The Canadian Government's Scientific Output: A Bibliometric Profile

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1. Introduction

The present report gives an overview of the Canadian government's scientific production between 1980 and 1998. The results are derived from the bibliometric database of the Observatoire des sciences et des technologies (OST). The database contains bibliometric information on publications from nearly 4 000 scientific journals, which are regarded by the scientific community as the most renown and reliable journals available. They are the most highly cited and give the best coverage of the most important scientific advances. With respect to the present study, they provide a solid basis upon which to compare the federal government's scientific output with that of other institutional sectors across Canada.

The federal government's scientific publications represent but one among many of its scientific pursuits. Much valuable work is in fact published in other types of scientific publications, such as highly specialized journals, journals of strictly national interest and, most of all, various official publications that are generally referred to as "gray literature" (minutes from conferences and symposiums, research reports, in-house journals, etc.)

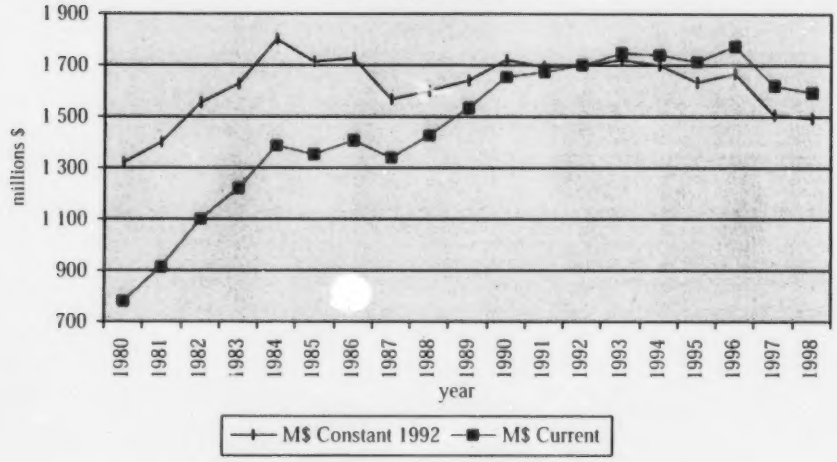
The publications contained in the OST's database do not therefore encompass the full range of the government's scientific activities. They do represent, however, the portion of its work that is the most visible to the national and international scientific communities. They are moreover relatively easy to quantify and enable us to produce reliable indicators of the government's research activity and of its involvement in collaborative scientific networks.

After briefly describing the federal government's financial investment in intramural R&D (section 2) since 1980, we proceed with a detailed analysis of the government's ensuing scientific production. In section 3, we examine the federal government's overall scientific production and the distribution of this production among the various governmental departments and agencies. Section 4 analyses the federal government's scientific publications in terms of the various disciplines involved. Using the impact factor, section 5 evaluates the quality of the publications produced by the various government departments and agencies. Section 6 describes the development of national and international collaborations among federal researchers. The conclusion outlines the main trends observed over the period and discusses some of their implications.

2. The Federal Government's Expenditures on R&D

The financial resources devoted to the federal government's intramural R&D have undergone significant reductions (in constant dollars) over the last 15 years (Figure 1). Following a period of sustained growth ending in 1984, budgets underwent a period of decline, due mainly to inflation, lasting until 1987. Resources grew again between 1988 and 1990, remained stable until 1994, and declined thereafter.

Figure 1
The Federal Government's Intramural Expenditures on R&D in Millions of Current Dollars and in Constant 1992 Dollars from 1980 to 1998



Sources : From 1987 to 1998: Stat Can, *Service Bulletin, Science Statistics*, vol 22, no 5, october 1998, table 3, p.4; from 1980 to 1986: Stat Can, *Service Bulletin, Science Statistics*, vol 20, no 6, september 1996, table 4, p.4; GDPPI : CANSIM database, label D23203.

Figure 2 shows federal government's intramural R&D expenditures by departments and agencies for the years 1989 to 1998. This measure reveals how the federal government concentrates its resources within a relatively small number of departments and agencies, seven of which produce approximately 90% of the government's intramural R&D.

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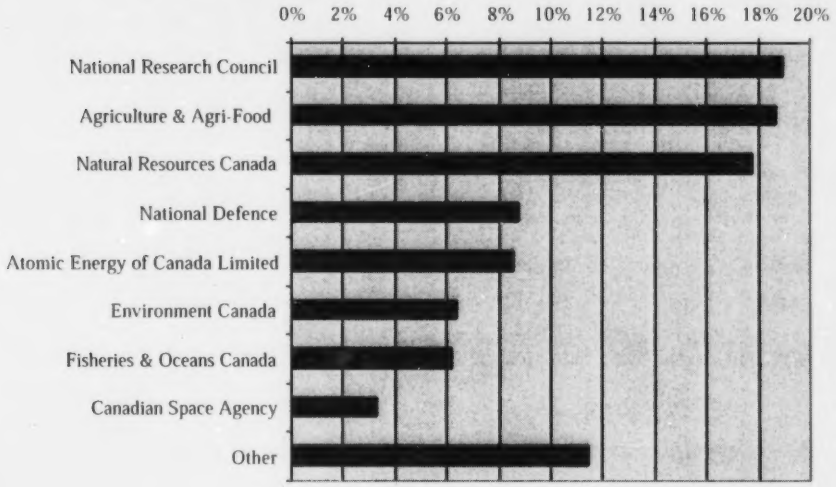
Figure 2
Distribution of Federal Intramural Expenditures on R&D
Broken Down by Department and Agency, 1989 to 1998



Source : Stat. Can., *Federal Government Expenditures and Personnel on Activities in the Natural and Social Sciences, 1989-90 to 1998-99*, September 1998, 88F0006XPB, no 9, tab 18, p.35.

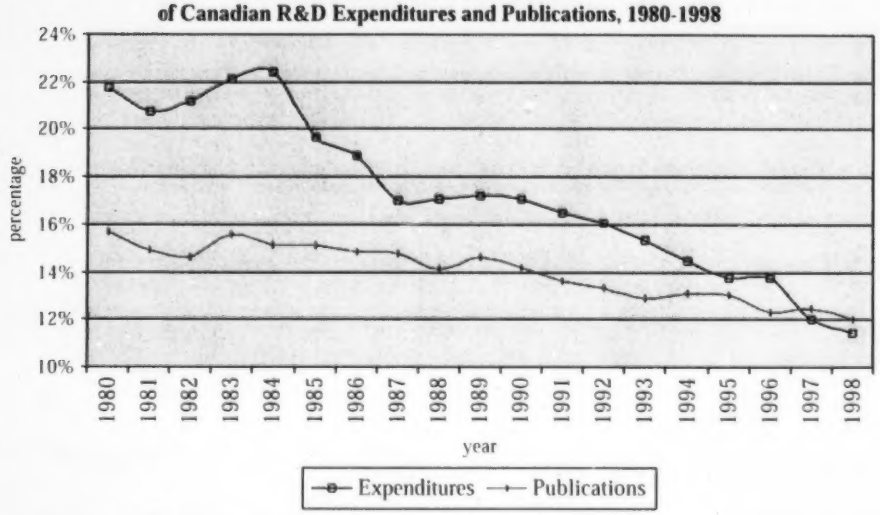
3. The Volume of Publications

Figure 3 shows a strong correlation between R&D expenditures and scientific output. The two curves represent the federal government's intramural R&D as a share of total Canadian expenditures in R&D and of Canadian scientific publications. As illustrated by the graph, the drop in the federal government's share of Canadian R&D expenditures corresponds to a comparable drop of its share of Canadian scientific publications.

Nevertheless it should also be noted that the curves converge with time. In 1980, the federal government's intramural research budgets represented 21,8% of Canadian Gross Expenditures on Research and Development (GERD) while its publications represented 15,7% of total Canadian output. In 1998, the situation had changed considerably in that the government's intramural R&D corresponded to 11,5% of Canada's GERD and to 12,0% of the country's total scientific output.

Because of the strong correlation between the data on federal expenditures and bibliometric data, the latter constitutes a reliable indicator of federal scientific production. We shall now concentrate our attention on it.

Figure 3
The Federal Government's Share
of Canadian R&D Expenditures and Publications, 1980-1998

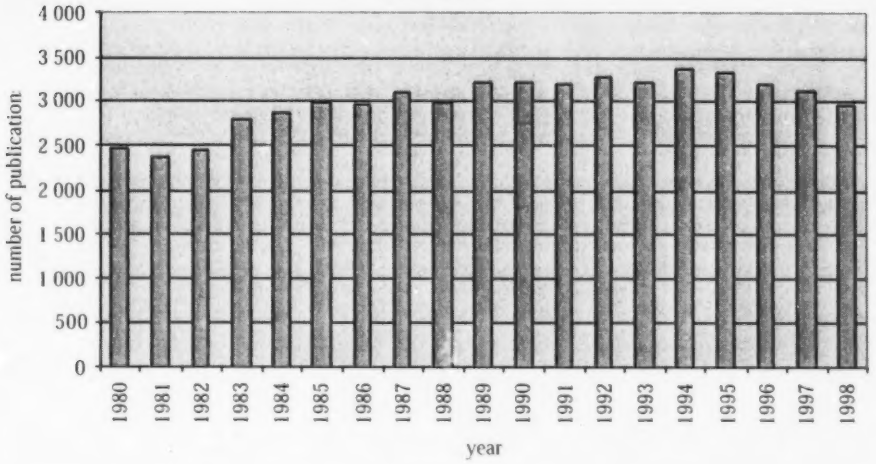


Sources : For Publications: Observatoire des sciences et des technologies.
For R&D Expenditures from 1987 to 1998: Stat Can, *Service Bulletin, Science Statistics*, vol 22, no 5, October 1998, table 3, p.4; from 1980 to 1986: Stat Can, *Service Bulletin, Science Statistics*, vol 20, no 6, September 1996, table 4, p.4.

The decrease in the federal government's relative share of Canadian publications is chiefly explained by the strong growth of Canadian scientific production in general. Indeed, between 1980 and 1998, Canadian scientific output went from 16 000 to over 25 000 yearly publications while over the same period the federal government's annual production went from 2 500 to approximately 3 000 publications (Figure 4). In absolute numbers, federal production never dropped dramatically. Rather, it grew slightly at the beginning of the 1980s and subsequently remained relatively stable (between 3 100 and 3 300) throughout the 1990s with a slight drop at the end of the decade. For the whole 1980-1998 period, it therefore underwent a 20% rate of growth while, over the same period, total Canadian output grew by 56%. As a matter of fact, the federal sector is, among all Canadian sectors performing R&D, the one with the smallest growth in publication output[1]. The federal share of Canadian publications thus went from 15,7% to 12,0%

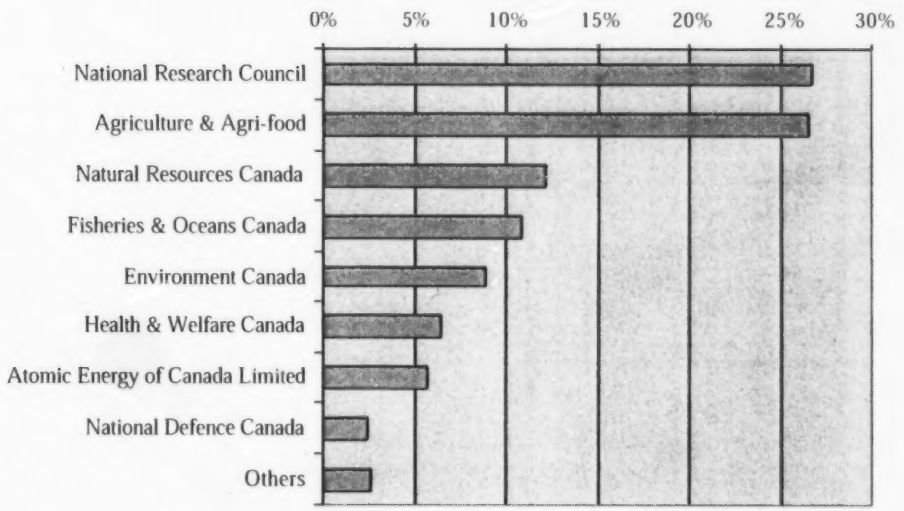
[1] Benoît Godin et Yves Gingras, « Impact of Collaborative Research on Academic Science », *Science and Public Policy*, vol 27, no 1, Feb. 2000. Benoît Godin and Yves Gingras, « The Impact of Collaborative Research on Scientific Production », *Research File*, vol 3, no 3, June 1999, 8 pages. http://www.aucc.ca/bilingue/research/collab_en.pdf

Figure 4
Total Number of Federal Publications
1980-1998



Source : Observatoire des sciences et des technologies

Figure 5
Federal Publication Broken Down
By Department and Agency
between 1980-1998



Source : Observatoire des sciences et des technologies

Figure 5 shows the share of federal publications produced by the various federal departments and agencies during the period under consideration. The largest publication

producers are the departments which also invest the most in intramural research. Two exceptions should be mentioned, however. Health Canada ranks sixth in terms of federal publications (Figure 5) but does not figure among the major recipients of R&D funding (Figure 2). Inversely, the Canadian Space Agency accounts for 3,3% of intramural federal R&D expenditures but produces less than 0,2% of federal publications.

Needless to say, it would be misguided to expect to find a perfect correspondence between a department's or agency's publication output and the relative size of its research budget. The costs entailed in producing a publication depend essentially upon the nature and scale of the research involved. One should also take into account the specific mandate and mission of these institutions.

4. The Disciplinary Distribution of Federal Publications

The OST's bibliometric database contains eight (8) major disciplinary fields subdivided into one hundred (100) specialities and allows us to precisely identify, therefore, the various disciplines in which federal scientists conduct their research.

Table 1
Federal Publications Broken Down by Discipline
Triennial Periods, 1980-1998

Field	1981-83	1984-86	1987-89	1990-92	1993-95	1996-98	TOTAL
Biology	36,2%	36,6%	36,3%	34,5%	32,7%	32,2%	34,7%
Biomedical Research	10,1%	9,8%	11,3%	12,4%	11,5%	11,5%	11,1%
Chemistry	11,4%	10,5%	10,2%	9,2%	8,5%	7,9%	9,5%
Clinical Medicine	6,7%	6,9%	6,6%	7,5%	7,3%	8,9%	7,3%
Earth and Space	15,4%	15,6%	17,3%	17,7%	20,7%	21,6%	18,2%
Engineering & Technology	7,0%	7,9%	7,3%	7,8%	8,1%	6,9%	7,5%
Mathematics	0,3%	0,3%	0,2%	0,2%	0,2%	0,2%	0,2%
Physics	12,7%	12,2%	10,6%	10,7%	10,9%	10,2%	11,2%
Unknown	0,2%	0,2%	0,1%	0,0%	0,0%	0,6%	0,2%
TOTAL N. publications in %	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
TOTAL N. publications	7 619	8 819	9 305	9 666	9 920	9 283	54 612

Source: Observatoire des sciences et des technologies

Table 1 shows that, between 1981 and 1998, more than a third (34,7%) of federal publications were produced in Biology. Then follow, in descending order, Earth and Space Science (18,2%), Physics (11,2%), Biomedical Research (11,1%), Chemistry (9,5%), Engineering (7,5%) and Clinical Medicine (7,3%). Mathematics (0,2%) follows far behind, remaining within the almost exclusive purview of university researchers.

We may also note a certain redistribution of research production between the beginning and end of the period under study. Biology's share decreased, for example, going from 36,2% to 32,2% between 1981-83 and 1996-98. Similarly, Chemistry's share went from 11,4% to 7,9% and Physics' from 12,7% to 10,2%. On the other hand, Biomedical Research, Clinical Medicine and, especially, Earth and Space Science experienced a marked increase in their share of scientific production over the same period.

Table 2
Federal Publications Broken Down by Speciality
Triennial Periods, 1981-1998

Speciality	1981-83	1984-86	1987-89	1990-92	1993-95	1996-98	TOTAL
Agricult & Food Science	11,1%	10,4%	11,7%	11,8%	10,8%	10,9%	11,1%
Botany	7,8%	8,6%	8,0%	7,2%	7,4%	6,5%	7,6%
Marine Biology & Hydrobiology	4,9%	6,3%	7,1%	6,0%	6,0%	5,7%	6,0%
Environmental Science	4,4%	4,2%	4,2%	4,1%	5,8%	5,8%	4,8%
Earth & Plantry Science	4,6%	3,8%	4,8%	4,7%	5,3%	4,2%	4,6%
Dairy & Animal Science	3,2%	3,1%	3,2%	3,9%	3,9%	3,3%	3,4%
Biochemistry & Molecular Biology	4,0%	3,9%	3,4%	3,4%	2,8%	2,8%	3,4%
Entomology	4,8%	3,8%	3,0%	3,0%	2,8%	2,6%	3,3%
Analytical Chemistry	3,0%	2,8%	2,8%	2,5%	3,3%	2,8%	2,9%
Astronmy & Astrophys	2,9%	2,9%	2,5%	2,3%	2,5%	2,9%	2,6%
Geology	1,6%	2,0%	2,6%	3,1%	3,1%	3,5%	2,7%
Chemical Physics	3,5%	3,1%	2,4%	2,0%	1,9%	1,7%	2,4%
Physical Chemistry	2,9%	2,7%	2,8%	2,1%	2,0%	1,9%	2,4%
Applied Physics	2,4%	2,1%	2,1%	2,1%	2,6%	2,4%	2,3%
General Chemistry	3,2%	2,9%	2,3%	2,2%	1,5%	1,5%	2,2%
Microbiology	2,0%	2,0%	2,0%	2,4%	2,1%	2,4%	2,1%
General Physics	2,5%	2,3%	2,0%	2,2%	1,8%	2,0%	2,1%
Oceanography & Limnology	1,3%	2,0%	2,1%	2,0%	1,7%	2,0%	1,9%
Pharmacology	1,5%	1,5%	1,2%	1,9%	1,6%	1,7%	1,6%
Meteorol & Atmospheric Science	0,6%	0,7%	1,1%	1,5%	2,3%	3,2%	1,6%
Others (n = 80 specialities)	27,7%	29,0%	28,7%	29,6%	28,7%	30,1%	29,0%
TOTAL N. Publications in %	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
TOTAL N. Publications	7 619	8 819	9 305	9 666	9 920	9 283	54 612

Source: Observatoire des sciences et des technologies

The breakdown of publications by speciality in Table 2 provides a still sharper picture of the full range of federal scientific output. We may note that, over the entire period, five specialities (Agriculture and Food Science, Botany, Marine Biology and Hydrobiology, Environmental Science and Earth and Planetary Science) account for over a third (34,1%) of federal publications. The fifteen other specialities taken together account for about the same proportion of publications (36,9%), while the remaining share of publications (29,0%) are dispersed among the eighty (80) other specialities.

Table 3
Federal Share of Total Canadian Publication Output
According to Speciality, 1980-1998
(The 20 Most Important Federal Specialities)

Specialty	Total Canadian Publications	N. Federal publications	Fed. in % of Canadian Total
Oceanography & Limnology	2 057	1 049	51,0%
Agriculture & Food Science	13 372	6 405	47,9%
Meteorol & Atmospheric Science	1 919	908	47,3%
Entomology	4 251	1 910	44,9%
Environmental Science	6 786	2 702	39,8%
Nuclear Technology	1 404	553	39,4%
Dairy & Animal Science	5 055	1 945	38,5%
Marine Biology & Hydrobiology	9 078	3 441	37,9%
Analytical Chemistry	5 073	1 650	32,5%
Botany	14 188	4 325	30,5%
Astronomy & Astrophysics	5 384	1 493	27,7%
Earth & Plantry Science	10 414	2 621	25,2%
Optics	3 014	726	24,1%
Geology	6 701	1 489	22,2%
Acoustics	1 469	309	21,0%
Miscellaneous Biomedical Res.	1 371	288	21,0%
Applied Chemistry	605	127	21,0%
Aerospace Technology	744	148	19,9%
Microbiology	6 214	1 234	19,9%
Applied Physics	6 790	1 331	19,6%
TOTAL	105 889	34 654	32,7%

Source : Observatoire des sciences et des

Table 3 presents federal scientific output in the twenty specialities in which it makes its highest relative contribution to Canadian science. We may observe for example that more than half (51,0%) of all Canadian publications in Oceanography and Limnology were produced with the collaboration of at least one government researcher. Most of the specialities listed in Table 2, that is those that account for the largest share of the government's research output, are also listed in Table 3. In most cases, the government tends to be highly active in specialities that correspond to the specific mandates of departments with large research budgets.

We may be somewhat surprised, however, by the government's substantially large contributions in specialities like Analytical Chemistry (32,5% of Canadian publications), Astronomy and Astrophysics (27,7%), Optics (24,1%) and Applied

Chemistry (21,0%). Though some federal specialities do not account for a very large proportion of federal publications, they generate a relatively large share of Canadian publications in their own areas of specialization. It is the case with federal publications in Nuclear Technology, for instance, which make up for only 1% of total federal production but 39% of all Canadian publications in this speciality (Table 3). It is also the case for Optics (24,1% of Canadian production), Applied Chemistry (21,0%), Acoustics (21,0%) and Miscellaneous Biomedical Research (21,0%). We should nevertheless point out that the federal government's contribution to Canadian production remains marginal in Biochemistry, General Chemistry, Physical Chemistry, General Physics, Chemical Physics and Pharmacology, despite the large number of federal publications in these six specialities. These specialities appear in Table 2, for instance, but not in Table 3.

Table 4
The Federal Government's Specialization Index
According to Disciplinary Fields,
(Reference: Canada = 1,0)
1980-1998 (some years)

Field	1980	1985	1990	1995	1998
Biology	2,4	2,3	2,3	2,5	2,7
Biomedical Research	0,7	0,6	0,7	0,7	0,6
Chemistry	1,0	1,0	1,1	1,0	0,8
Clinical Medicine	0,2	0,2	0,2	0,3	0,3
Earth And Space	1,9	2,1	2,2	2,4	2,5
Engineering & Technology	0,8	0,9	0,9	0,9	0,9
Mathematics	0,2	0,1	0,1	0,1	0,1
Physics	1,1	1,2	1,0	1,0	1,0

Source: Observatoire des sciences et des technologies

The specialization index constitutes another way by which to appreciate the relative federal contribution to Canadian scientific production. As indicated by its name, this index allows us to identify the areas of specialization of an institution, a group of institutions or a given institutional sector, by comparing them with the specialization patterns of all Canadian researchers. An index above 1,0 indicates that the government produces a larger share of its publications in a given discipline than Canadian researchers in general. According to Table 4, therefore, the federal government is more highly specialized in the fields of Biology (index between 2,3 and 2,7) and Earth and Space Science (index between 1,9 and 2,5) than Canadian researchers in general. The government devoted a share of publications to Chemistry and Physics comparable to that which was devoted by Canadian researchers as a whole (index around 1,0). Its contributions to Biomedical Research, Clinical Medicine and Mathematics were relatively small. We note, furthermore, that over the entire period the index remained

fairly stable in seven of the eight fields but underwent a steady increase in Earth and Space Science.

Table 5 presents the development of the federal government's specialization index in the twenty (20) specialities in which it made its largest contributions to Canadian science (see Table 3). We note that, in the majority of specialities, the index remained relatively stable throughout the period under consideration. It rose significantly, however, in the Meteorological and Atmospheric Sciences, Geology and Acoustics, and fell noticeably in Applied Chemistry.

Table 5
The Federal Government's Specialization Index According to Specialty, 1980-1998
(Reference: Canada = 1,0)
(some years)
(The 20 Most Productive Federal Specialities)

Specialty	1980	1985	1990	1995	1998
Oceanography & Limnology	3,2	3,9	4,0	3,2	3,7
Agriculture & Food Science	3,5	3,2	3,2	3,6	3,8
Meteorol & Atmospheric Science	2,1	2,6	3,6	3,6	4,0
Entomology	3,1	3,2	2,9	3,3	3,7
Environmental Science	2,6	2,7	2,8	3,4	2,9
Nuclear Technology	3,8	2,2	2,1	2,4	3,1
Dairy & Animal Science	2,8	2,8	2,5	2,8	2,8
Marine Biology & Hydrobiology	2,7	2,7	2,7	2,7	2,6
Analytical Chemistry	2,3	2,3	2,2	2,7	2,2
Botany	2,2	2,2	2,0	2,3	2,4
Astronomy & Astrophysics	1,8	2,5	1,7	1,9	2,5
Earth & Plantry Science	1,9	1,5	1,8	1,9	1,9
Optics	1,9	1,8	1,3	1,4	1,9
Geology	0,9	1,2	1,9	1,7	1,9
Acoustics	0,8	1,9	1,5	1,7	1,7
Miscellaneous Biomedical Res.	1,0	1,9	1,2	1,3	1,5
Applied Chemistry	2,6	1,4	0,7	1,9	0,7
Aerospace Technology	2,5	0,9	1,0	0,9	2,0
Microbiology	1,6	1,3	1,4	1,4	1,6
Applied Physics	1,8	1,4	1,3	1,3	1,6

Source: Observatoire des sciences et des technologies

5. The Quality of Publications

The impact factor presented in Table 6 represents the average number of citations received by a journal in a year that refer to the publications produced by this journal during the two preceding years. The score is subsequently assigned to each of the journal's publications. The impact factor is thus, strictly speaking, a measure of the

visibility, renown or influence of a journal and its publications. When applied to the publications of *a group of researchers*, moreover, the impact factor may serve as *a legitimate measure of research quality.*

Throughout the period, the government impact factors in the fields of Biology, Biomedical Research, Chemistry, Earth and Space Science, Engineering, and Physics, were comparable to those of Canadian researchers (Table 6). These factors were lower in Clinical Medicine and higher in Mathematics, however it should be mentioned that federal mathematicians only publish about ten publications a year.

Table 6
The Federal Government's Impact Factors by Discipline
1980, 1990 and 1998

Field	Federal Government			Canada		
	1980	1990	1998	1980	1990	1998
Biology	0,7	0,8	1,0	0,8	0,9	1,3
Biomedical Research	2,2	3,0	4,3	2,4	3,1	4,7
Chemistry	1,7	1,8	2,4	1,8	1,7	2,2
Clinical Medicine	1,3	1,9	2,2	1,9	2,3	3,0
Earth And Space	1,4	1,3	1,6	1,4	1,4	1,5
Engineering & Technology	0,7	0,6	0,7	0,6	0,6	0,7
Mathematics	0,6	1,0	0,9	0,4	0,5	0,6
Physics	2,1	2,2	1,9	1,9	2,1	2,1

Source: Observatoire des sciences et des technologies

Table 7 presents the government's impact factors in the 26 specialties in which it has firmly established itself on the Canadian scene (see Table 3) and in which it concentrates the lion's share of its research activities (see Table 2). We observe that in 1998, except in the cases of Miscellaneous Biomedical Research and Pharmacology, the impact factors of the government's publications were essentially comparable or higher than those of Canadian publications overall. Thus, in terms of the quality of the work produced in the government's most active disciplines, federal researchers have no cause to be envious of their Canadian research peers.

Table 7
Federal Government Impact Factors by Speciality
1980, 1990 and 1998
(26 most active government specialities)

Speciality	Federal Government			Canada		
	1980	1990	1998	1980	1990	1998
Oceanography & Limnology	1,8	1,0	2,3	1,9	1,1	2,2
Agriculture & Food Science	0,6	0,6	0,8	0,6	0,6	0,8
Meteorol & Atmospheric Science	1,7	1,2	1,8	1,5	1,2	1,7
Entomology	0,5	0,8	0,9	0,6	0,8	0,9
Environmental Science	1,0	0,9	1,7	1,0	0,9	1,5
Nuclear Technology	1,1	0,5	0,9	1,0	0,7	1,0
Dairy & Animal Science	0,8	0,9	0,9	0,8	0,9	1,1
Marine Biology & Hydrobiology	0,9	1,2	1,4	0,9	1,1	1,4
Analytical Chemistry	1,7	1,6	2,3	1,8	1,8	2,5
Botany	0,8	0,9	1,2	1,0	1,1	1,4
Astronmy & Astrophysic	2,5	2,4	1,5	2,6	2,5	1,6
Earth & Plantry Science	1,2	1,2	1,3	1,1	1,2	1,2
Optics	1,7	1,2	1,0	1,5	1,6	1,2
Geology	0,9	1,4	1,3	1,2	1,4	1,3
Acoustics	1,3	1,2	1,0	0,9	1,0	1,0
Miscellaneous Biomedical Res.	0,6	0,6	0,8	0,6	1,1	1,5
Applied Chemistry	0,6	0,6	1,1	0,5	0,7	1,1
Aerospace Technology	0,1	0,4	0,5	0,2	0,3	0,5
Microbiology	1,4	2,1	2,3	1,5	2,2	2,8
Applied Physics	1,6	1,8	1,9	1,5	1,6	1,6
Biochemistry & Molecular Biology	2,9	3,3	4,0	2,9	3,4	4,6
Chemical Physics	2,5	2,6	2,4	2,5	2,5	2,3
Physical Chemistry	1,3	1,7	1,8	1,4	1,5	1,7
General Chemistry	2,4	2,2	4,5	2,1	2,0	2,8
General Physics	2,7	3,1	2,4	1,5	2,2	2,4
Pharmacology	1,4	1,4	1,3	1,9	2,0	2,2

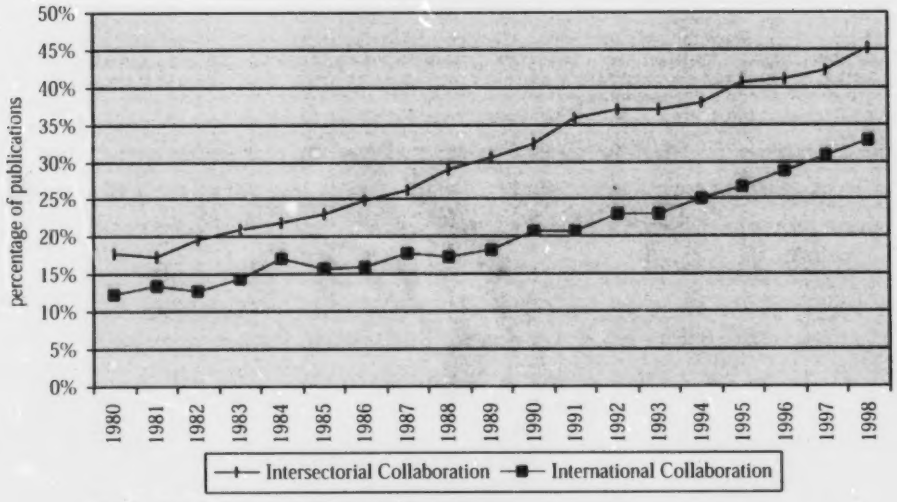
Source: Observatoire des sciences et des technologies

6. The Collaborations

Like other Canadian scientists, federal researchers have intensified their collaborative work with national and international partners. Between 1980 and 1998, the proportion of government publications cosigned with national partners from other institutional sectors went from 17,7% to 45,1%. During the same period, the proportion of its

international collaborations went from 12,4% to 32,9% (Figure 6). We have observed a similar increase of international collaborations in Canadian publications overall[2].

Figure 6
Proportion of Federal Publications
Produced in Intersectorial and International Collaboration
1980-1998



Source : Observatoire des sciences et des technologies

6.1. THE NATIONAL COLLABORATIONS

The university sector supplies federal researchers with their greatest number of national collaborators and, thus, over 80% of their yearly coauthorships. The industry sector comes a distant second, followed by the provincial and hospital sectors.

We should note that, despite the fairly substantial increase in the proportion of articles produced with national partners between 1980 and 1998, the relative proportions in each of the major categories of collaborators (university, industry, provincial, hospital and other) remain quite stable throughout the period studied. Intersectoral collaborations intensify with time, but the fundamental structure of these collaborations varies little.

[2] Benoît Godin, Yves Gingras et Martine Foisy, « The Internationalization of University Research in Canada », in Sheryl L Bond and Jean-Pierre Lemasson, dirs. *A New World of Knowledge : Canadian Universities and Globalization*, Ottawa, International Development Research Center, 1999, pp. 77-98.

Table 8
Federal Collaborations with National Partners by Institutional Sector
1980-1998

Year	University	Industry	Provincial	Hospital	Unknown	Others	N. Publications
1980	85,1%	10,1%	6,2%	1,6%	0,0%	1,6%	436
1981	83,4%	12,3%	6,7%	2,6%	0,0%	1,4%	416
1982	83,9%	12,8%	6,1%	2,1%	0,0%	1,7%	478
1983	83,4%	11,0%	5,5%	2,1%	0,2%	3,8%	584
1984	83,1%	12,1%	6,4%	2,1%	0,0%	2,4%	628
1985	84,5%	10,4%	5,8%	2,3%	0,4%	2,2%	685
1986	83,4%	12,0%	8,2%	2,4%	0,0%	2,0%	736
1987	81,1%	14,5%	8,2%	4,2%	0,2%	1,8%	815
1988	81,9%	15,0%	8,0%	4,6%	0,0%	2,0%	864
1989	83,7%	11,3%	6,6%	3,3%	0,1%	2,9%	982
1990	86,3%	12,1%	7,3%	3,4%	0,1%	2,6%	1039
1991	82,3%	12,9%	8,7%	2,4%	0,1%	3,7%	1144
1992	84,7%	12,6%	6,8%	3,8%	0,1%	3,1%	1211
1993	86,4%	10,5%	7,0%	3,4%	0,0%	3,9%	1192
1994	86,4%	10,6%	6,6%	3,4%	0,2%	2,8%	1278
1995	85,3%	9,7%	7,1%	2,8%	0,4%	3,8%	1358
1996	85,5%	11,0%	7,6%	3,5%	0,2%	4,7%	1309
1997	85,8%	11,9%	8,7%	4,4%	0,2%	3,5%	1321
1998	85,4%	12,8%	8,4%	4,3%	0,3%	3,4%	1340

Source: Observatoire des sciences et des technologie

6.2. THE INTERNATIONAL COLLABORATIONS

The United-States supplies Canadian federal researchers with their largest pool of foreign collaborators, followed by the United-Kingdom, then France, Germany, Japan and Australia (Table 9).

In contrast to national collaborations which intensified without fundamentally altering the relative share of collaborative activity in each of the major categories of collaborators, the rise in international collaborations is marked by a certain diversification of partners. While the share of federal research collaborations remain quite stable for the United-States and United-Kingdom, it tended to increase for Germany, Japan and Italy over the same period. Even more striking is the growth in the proportion of collaborations undertaken with other countries. Between 1980 and 1998, their share increased from 24% to 43% of federal coauthorships.

Table 9
International Collaborations According to Principal Partners
1980-1998

Year	United States	United Kingdom	France	Germany	Japan	Australia	Sweden	Italy	Others	N. publications
1980	56.7%	10.2%	7.5%	5.6%	3.6%	3.0%	1.6%	0.0%	23.6%	305
1981	55.0%	15.2%	8.4%	5.3%	4.0%	3.7%	0.3%	3.1%	23.3%	322
1982	56.3%	15.1%	6.1%	3.2%	3.9%	2.3%	1.3%	2.3%	22.2%	311
1983	54.6%	13.2%	7.0%	5.0%	1.7%	2.5%	2.0%	1.7%	25.9%	401
1984	53.9%	11.8%	11.4%	6.7%	3.0%	4.3%	2.0%	1.8%	24.4%	492
1985	53.1%	11.0%	11.5%	4.7%	3.2%	3.8%	1.5%	3.2%	24.2%	471
1986	49.0%	13.3%	7.2%	5.7%	4.2%	3.0%	2.3%	2.5%	24.9%	473
1987	54.2%	11.6%	6.5%	6.1%	4.0%	2.9%	2.5%	3.3%	29.3%	553
1988	53.7%	11.5%	9.2%	6.9%	3.5%	2.7%	2.7%	2.1%	29.0%	521
1989	55.9%	11.4%	7.6%	7.6%	4.9%	3.4%	2.4%	3.1%	28.9%	589
1990	57.0%	14.0%	9.0%	8.5%	5.7%	2.8%	2.5%	3.1%	33.6%	670
1991	53.6%	10.9%	8.2%	9.0%	4.3%	2.1%	1.5%	3.8%	32.5%	658
1992	50.7%	12.7%	15.2%	8.3%	6.8%	3.6%	4.1%	3.6%	37.4%	755
1993	50.3%	12.0%	8.9%	7.4%	5.5%	4.7%	2.2%	2.0%	34.9%	740
1994	49.1%	10.1%	8.5%	8.8%	6.5%	3.9%	4.9%	2.9%	33.6%	849
1995	52.6%	10.7%	11.6%	9.0%	6.4%	3.7%	3.7%	3.9%	33.0%	891
1996	53.1%	12.3%	8.3%	9.9%	5.4%	4.0%	3.4%	3.4%	36.8%	911
1997	52.5%	10.5%	10.1%	8.3%	6.9%	3.9%	3.0%	2.5%	40.4%	965
1998	52.6%	13.9%	7.7%	9.7%	7.1%	7.0%	5.8%	2.6%	43.4%	976

Source : Observatoire des sciences et des technologie

7. Conclusion

The data presented in this study show beyond any doubt the major importance of the federal government's contribution to the advancement of Canadian science. In 1998, it produces 12% all Canadian scientific publications. During the considered period (1980-98), it contributed over a third of Canadian publications in eight (8) disciplinary specialities. Moreover, in the disciplines in which they have distinguished themselves the most, federal researchers have, in terms of the quality of their publications, no cause to be envious of Canadian researchers in general. Finally, the bibliometric data show federal researchers to be very well "networked", as much with national as with international partners.

Over the course of the last nineteen years, however, the heavy budgetary restrictions imposed upon federal R&D have, as we have seen, compromised its scientific production to a very considerable degree. We may well wonder, then, what effect the current regime's ongoing austerity measures will have not only upon federal science, but upon Canadian science in general.

Annex 1 : Definitions

1) Specialization Index (Reference: Canada = 1,0)

This index is calculated as follows :

$$\frac{\text{share (\%) of publications of institution X in field Z}}{\text{share (\%) of publications among all Canadian institutions in field Z}}$$

The specialization index indicates whether an institution or (in the present case) a government is more or less "specialized" (that is active) in a particular field in comparison to other institutions of the country. For example:

- The federal government has 360 publications in Biomedical Research in a total of 3 100 publications in all disciplines (which means that 12% of its publications are in this field)

- Canadian researchers published a total of 4 200 publications in Biomedical Research and of 25 000 publications overall (17% of its publications).

The government's specialization index is therefore 0,7 (12% divided by 17%), which indicates that it is not specialized in this field. In other words, it is less active in this field that the average level of activity in this field among Canadian Institutions. If the index is greater than 1, it indicates that the institution is more active in a given field than the average level of activity in that field among Canadian institutions.

2) The Impact Factor

The impact factor of a journal for a given year, say 1996, is calculated as follows :

$$\frac{\text{Number of citations received in 1996 by the publications that appeared in the journal in 94 and 95}}{\text{Number of publications that appeared in the journal in 1994 and 1995}}$$

To obtain the average impact factor, each publication is given the impact factor of the journal in which it is published. Therefore, an institution with researchers who publish in journals with high impact factors in a given field will obtain a high impact factor in this field.

Annex 2 : The Eight Disciplinary Fields and Their Specialities

Biology
Agriculture & Food Science
Botany
Dairy & Animal Science
Ecology
Entomology
General Biology
General Zoology
Marine Biology & Hydrobiology
Miscellaneous Biology
Miscellaneous Zoology

Biomedical Research
Anatomy & Morphology
Biochemistry & Molecular Biology
Biomedical Engineering
Biophysics
Cell Biology, Cytology & Histology
Embryology
Genetics & Heredity
General Biomedical Research
Microbiology
Microscopy
Miscellaneous Biomedical Research
Nutrition & Dietetic
Parasitology
Physiology
Virology

Chemistry
Analytical Chemistry
Applied Chemistry
General Chemistry
Inorganic & Nuclear Chemistry
Organic Chemistry
Physical Chemistry
Polymers

Clinical Medicine
Addictive Diseases
Allergy
Anesthesiology
Arthritis & Rheumatism
Cancer
Cardiovascular System
Dentistry
Dermatology & Venereal Diseases
Endocrinology
Fertility
Gastroenterology
General & Internal Medicine
Geriatrics
Hematology
Hygiene & Public Health
Immunology
Miscellaneous Clinical Medicine
Nephrology
Neurology & Neurosurgery
Obstetrics & Gynecology
Ophthalmology
Orthopedics
Otorhinolaryngology
Pathology
Pediatrics
Pharmacology
Pharmacy
Psychiatry
Radiology & Nuclear Medicine
Respiratory System
Surgery
Tropical Medicine
Urology
Veterinary Medicine

Earth And Space
Astronomy & Astrophysics
Earth & Plantry Science
Environmental Science
Geography
Geology
Meteorology & Atmospheric Sciences
Oceanography & Limnology

Engineering & Technology
Aerospace Technology
Chemical Engineering
Civil Engineering
Computers
Electrical Engineering & Electronic
General Engineering
Industrial Engineering
Library & Information Science
Materials Science
Mechanical Engineer
Metals & Metallurgy
Miscellaneous Engineering & Technology
Nuclear Technology
Optical Research & Management Science

Mathematics
Applied Mathematics
General Mathematics
Miscellaneous Mathematics
Probability & Statistics

Physics
Acoustics
Applied Physics
Chemical Physics
Fluids & Plasmas
General Physics
Miscellaneous Physic
Nuclear & Particle Physic
Optics
Solid State Physics